

## CLAIMS

What is claimed is:

1. A connection protection mechanism for an optical cross-connect switch, the connection protection mechanism comprising:

the optical cross-connect switch to couple to client equipment, the optical cross-connect switch to bi-directionally transport optical signals with the client equipment, the optical cross-connect switch including

one or more working ports to couple to the client equipment, each of the one or more working ports to couple to the client equipment using a pair of working links, and

a protection port to couple to the client  
equipment using a pair of protection links;  
and

a signaling channel to transport a connection failure signal indicating if one working port of the one or more working ports has a connection failure in its working link or the one working port coupling to the client equipment.

2. The connection protection mechanism of claim 1  
wherein,

if the one working port of the one or more working ports has the connection failure, the optical cross-connect switch to switch the coupling to the client

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6 equipment from the one working port to the protection  
7 port.

1 3. The connection protection mechanism of claim 1  
2 wherein,  
3 the optical cross-connect switch is without an  
4 optical-electrical-optical converter (O/E/O) but has a  
5 sensor to detect the connection failure.

1 4. The connection protection mechanism of claim 1  
2 wherein,  
3 the client equipment includes one or more of the set  
4 of wavelength division multiplexed (WDM) line terminals,  
5 SONET add/drop multiplexers, internet protocol (IP)  
6 routers, additional optical cross-connect switches and  
7 Asynchronous Transfer Mode (ATM) switches.

1 5. The connection protection mechanism of claim 1  
2 wherein,  
3 the optical cross-connect switch further includes  
4 at least one network port to couple to a  
5 network to bi-directionally transport optical  
6 signals with the network.

1 6. The connection protection mechanism of claim 5  
2 wherein,  
3 the optical cross-connect switch further includes  
4 a first optical switch fabric of optical  
5 switches to connect at least one pair of optical

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6      signals between the network equipment and the client
7      equipment.
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1        7.     The connection protection mechanism of claim 1  
2        wherein,  
3               the optical cross-connect switch further includes a  
4        first optical switch fabric, and  
5               if the one working port of the one or more working  
6        ports has the connection failure, the first optical  
7        switch fabric to switch the coupling to the client  
8        equipment through the one working port to the protection  
9        port.

1           8.    The connection protection mechanism of claim 1  
2           wherein,  
3                the signaling channel is an out-of-band signaling  
4           channel.

1        9.     The connection protection mechanism of claim 8  
2        wherein,  
3               the out-of-band signaling channel is a communication  
4        channel over a network.

1        10. The connection protection mechanism of claim 9  
2        wherein,  
3                the optical cross-connect switch further includes  
4                a network management controller to couple to a  
5                network and the one or more working ports and the  
6                protection port, the network management controller

1        14. The connection protection mechanism of claim 8  
2        wherein,  
3                the in-band signaling channel is a dedicated  
4        signaling link in parallel with each of the pair of  
5        working links.

1 15. The connection protection mechanism of claim 6  
2 wherein,  
3 the optical cross-connect switch further includes  
4 a second optical switch fabric of optical  
5 switches to provide a redundant optical switch  
6 fabric in case of a failure in the first optical  
7 switch fabric,  
8 and  
9 wherein if the one working port of the one or more  
10 working ports has the connection failure, the second  
11 optical switch fabric to switch the coupling to the  
12 client equipment through the one working port to the  
13 protection port.

1 16. The connection protection mechanism of claim 1  
2 wherein,  
3 the optical cross-connect switch further includes  
4 a second protection port to couple to the  
5 client equipment using a second pair of protection  
6 links  
7 and,  
8 wherein if the one working port of the one or more  
9 working ports has the connection failure, the optical  
10 cross-connect switch to switch the coupling to the client  
11 equipment from the one working port to the second  
12 protection port.

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1           17. The connection protection mechanism of claim 6  
2           wherein,  
3                     the optical switches of the optical switch fabric  
4           are micro-machined mirrors to direct optical signals  
5           between the client and the network.

1           18. A method for protecting connections between an  
2   optical cross-connect switch and a client, the method  
3   comprising:

4                   detecting a connection failure on a working  
5           link of a pair of working links between the optical  
6           cross-connect switch and the client;  
7                   signaling the optical cross-connect switch or  
8           the client of the connection failure in response to  
9           detecting the connection failure; and  
10                   switching to a pair of protection links between  
11           the optical cross-connect switch and the client from the  
12           pair of working links having the connection failure.

1        19. The method of claim 18 wherein,  
2                the optical cross-connect switch is without an  
3        optical-electrical-optical converter (O/E/O) but has a  
4        sensor to detect the connection failure.

1        20. The method of claim 18 wherein,  
2        the client includes one or more of the set of  
3        wavelength division multiplexed (WDM) line terminals,  
4        SONET add/drop multiplexers, internet protocol (IP)



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1        27. The method of claim 18 wherein,  
2                the connection failure is detected by the client in  
3        the working link from the optical cross-connect switch to  
4        the client, and the client signals the connection failure  
5        to the optical cross-connect switch by  
6                disabling optical signal propagation from the client  
7        to the optical cross-connect switch over the working link  
8        from the client to the optical cross-connect switch  
9        without the connection failure of the pair of working  
10       links with the connection failure.





6 failure in a working link in one of the one or more I/O  
7 port cards.

1 31. The connection protection interface of claim 29  
2 wherein,  
3 each of the working optical links is a pair of  
4 optical fiber and each of the protection optical links is  
5 a pair of optical fibers.

1 32. The connection protection interface of claim 29  
2 wherein,  
3 each of the working optical links is a single  
4 optical fiber and each of the protection optical links is  
5 a single optical fiber.

1 33. The connection protection interface of claim 29  
2 wherein,  
3 M is greater than or equal to one and N is greater  
4 than or equal to one.

1 34. The connection protection interface of claim 29  
2 wherein,  
3 each of the one or more I/O port cards of the  
4 optical cross-connect switch is without an optical-  
5 electrical optical converter (O/E/O) but each has a  
6 sensor to detect the connection failure between the  
7 client equipment and the optical cross-connect switch.

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1 35. The connection protection interface of claim 29  
2 wherein,  
3 the client equipment includes one or more of the set  
4 of wavelength division multiplexed (WDM) line terminals,  
5 SONET add/drop multiplexers, internet protocol (IP)  
6 routers, additional optical cross-connect switches and  
7 Asynchronous Transfer Mode (ATM) switches.

1           36. The connection protection interface of claim 29  
2           wherein,  
3                 the one or more I/O port cards to communicate with  
4           the client equipment are client port cards.

1           37. The connection protection interface of claim 29  
2           wherein,  
3                 at least one I/O port card to communicate with a  
4           network and is a network port card.

1 38. The connection protection interface of claim 29  
2 wherein,  
3 each of the one or more I/O port cards further has a  
4 dedicated signal line to couple to a respective I/O port  
5 card of the client equipment, the dedicated signal line  
6 to transmit and receive connection failure signals  
7 regarding the connection between the optical cross-  
8 connect switch and the client equipment.

1 39. The connection protection interface of claim 29  
2 further comprising:

3 an out of band signaling channel to transmit a  
4 connection failure signal in response to the sensor  
5 detecting a connection failure in a working link from the  
6 client equipment to the optical cross-connect switch.

1 40. The connection protection interface of claim 39  
2 wherein,

3 the connection failure signal indicates the  
4 connection failure and which of the one or more I/O  
5 port cards has the connection failure.

1 41. The connection protection interface of claim 29  
2 wherein,

3 the connection failure is detected by the optical  
4 cross-connect switch in a working link from the client  
5 equipment to the optical cross-connect switch, and the  
6 optical cross-connect switch signals the connection  
7 failure to the client equipment by

8 disabling optical signal propagation from the  
9 optical cross-connect switch to the client equipment over  
10 the working link without the connection failure of the  
11 one I/O port card of the one or more I/O port cards with  
12 the connection failure.

1 42. The connection protection interface of claim 29  
2 wherein,

the connection failure is detected by the optical cross-connect switch in a working link from the client equipment to the optical cross-connect switch, and the optical cross-connect switch signals the connection failure to the client equipment by

transmitting an optical signal having a pattern over the working link without the connection failure of the one I/O port card of the one or more I/O port cards with the connection failure, the optical signal having the pattern indicating the connection failure in the working link from the client to the optical cross-connect switch.

43. The connection protection interface of claim 42 wherein,

the pattern of the optical signal indicates the connection failure and which of the one or more I/O port cards has the connection failure.

44. A protected connection between an optical cross-connect switch and a client equipment in a communication network system, the protected connection comprising:

one or more pairs of optical links coupled between the optical cross-connect switch and the client equipment as working links over which optical signals ordinarily propagate without a connection failure; and

at least one pair of optical links coupled between the optical cross-connect switch and the client equipment as protection links over which optical signals can

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11         atypically propagate in the event of a connection
12         failure.

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1        45.    The protected connection of claim 44 wherein,  
2                the optical cross-connect switch includes,  
3                        one or more input/output (I/O) ports coupled to  
4                the one or more pairs of optical links as the  
5                working links to connect and bi-directionally  
6                transport optical signals with the client equipment,  
7                and

8                   at least one protection port to couple to the  
9                   at least one pair of optical links as the protection  
10                  links to connect with the client equipment and  
11                  atypically bi-directionally transport optical  
12                  signals with the client equipment in the event of a  
13                  connection failure in the working links of the one  
14                  or more pairs of optical links;  
15                  and

the client equipment includes,  
one or more I/O ports coupled to the one or  
more pairs of optical links as the working links to  
connect and bi-directionally transport optical  
signals with the optical cross-connect switch, each  
of the one or more I/O ports having a sensor to  
detect a connection failure between the client  
equipment and the optical cross-connect switch, and

24                   at least one protection port to couple to the  
25                   at least one pair of optical links as the protection

1. The first group of people who are interested in the study of the history of the world are the historians. They are the people who study the past and write about it. They are the people who tell us what happened in the past and why it happened. They are the people who help us to understand the world around us.

26 links to connect with the optical cross-connect  
27 switch and atypically bi-directionally transport  
28 optical signals with the optical cross-connect  
29 switch in the event of a connection failure in the  
30 working links of the one or more pairs of optical  
31 links.

1        46. The protected connection of claim 45 wherein,  
2                the one or more I/O ports of the optical cross-  
3        connect switch are without an optical-electrical-optical  
4        converter (O/E/O) but each has a sensor to detect a  
5        connection failure between the client equipment and the  
6        optical cross-connect switch.

1        47. The protected connection of claim 44 wherein,  
2                the client equipment includes one or more of the set  
3        of wavelength division multiplexed (WDM) line terminals,  
4        SONET add/drop multiplexers, internet protocol (IP)  
5        routers, additional optical cross-connect switches and  
6        Asynchronous Transfer Mode (ATM) switches.

1        48. The protected connection of claim 44 further  
2        comprising:  
3                an out-of-band signaling channel between the client  
4        equipment and the optical cross-connect switch, the out-  
5        of-band signaling channel to transmit a connection  
6        failure signal in response to detection of a connection  
7        failure in the working links between the client equipment  
8        and the optical cross-connect switch.





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7            disabling optical signal transport from the optical  
8            cross-connect switch to the client equipment over another  
9            optical link without the connection failure of the pair  
10           of optical links.

1        56. The protected connection of claim 51 wherein,  
2                the connection failure is detected by an I/O port of  
3        the optical cross-connect switch in an optical link of a  
4        pair of optical links and the optical cross-connect  
5        switch signals the connection failure to the client  
6        equipment by  
7                transmitting an optical signal having a pattern over  
8        another optical link without the connection failure of  
9        the pair of optical links, the optical signal having the  
10       pattern indicating the connection failure in the optical  
11       link.

1        57. The protected connection of claim 51 wherein,  
2                the connection failure is detected by an I/O port of  
3        the client equipment in an optical link of a pair of  
4        optical links and the client equipment signals the  
5        connection failure to the optical cross-connect switch by  
6                disabling optical signal transport from the client  
7        equipment to the optical cross-connect switch over  
8        another optical link without the connection failure of  
9        the pair of optical links.

1        58. The protected connection of claim 51 wherein,  
2                the connection failure is detected by an I/O port of  
3        the client equipment in an optical link of a pair of  
4        optical links and the client equipment signals the  
5        connection failure to the optical cross-connect switch by

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6           transmitting an optical signal having a pattern over  
7           another optical link without the connection failure of  
8           the pair of optical links, the optical signal having the  
9           pattern indicating the connection failure in the optical  
10          link.

1           59. A connection protection mechanism for optical  
2 network equipment, the connection protection mechanism  
3 comprising:

4           the optical network equipment to couple to client  
5           equipment, the optical network equipment to bi-  
6           directionally transport optical signals with the client  
7           equipment, the optical network equipment including  
8           one or more working ports to couple to the  
9           client equipment, each of the one or more working  
10          ports to couple to the client equipment using a pair  
11          of working links, and

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12             a protection port to couple to the client
13             equipment using a pair of protection links;
14             and

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15           a signaling channel to transmit and receive a  
16       connection failure signal indicating if one working port  
17       of the one or more working ports has a connection failure  
18       in a working link or a working port coupling to the  
19       client equipment.

1           60. The connection protection mechanism of claim 59  
2           wherein,

1

1.  $\frac{1}{2}$  2.  $\frac{1}{2}$  3.  $\frac{1}{2}$  4.  $\frac{1}{2}$  5.  $\frac{1}{2}$  6.  $\frac{1}{2}$  7.  $\frac{1}{2}$  8.  $\frac{1}{2}$  9.  $\frac{1}{2}$  10.  $\frac{1}{2}$  11.  $\frac{1}{2}$  12.  $\frac{1}{2}$  13.  $\frac{1}{2}$  14.  $\frac{1}{2}$  15.  $\frac{1}{2}$  16.  $\frac{1}{2}$  17.  $\frac{1}{2}$  18.  $\frac{1}{2}$  19.  $\frac{1}{2}$  20.  $\frac{1}{2}$  21.  $\frac{1}{2}$  22.  $\frac{1}{2}$  23.  $\frac{1}{2}$  24.  $\frac{1}{2}$  25.  $\frac{1}{2}$  26.  $\frac{1}{2}$  27.  $\frac{1}{2}$  28.  $\frac{1}{2}$  29.  $\frac{1}{2}$  30.  $\frac{1}{2}$  31.  $\frac{1}{2}$  32.  $\frac{1}{2}$  33.  $\frac{1}{2}$  34.  $\frac{1}{2}$  35.  $\frac{1}{2}$  36.  $\frac{1}{2}$  37.  $\frac{1}{2}$  38.  $\frac{1}{2}$  39.  $\frac{1}{2}$  40.  $\frac{1}{2}$  41.  $\frac{1}{2}$  42.  $\frac{1}{2}$  43.  $\frac{1}{2}$  44.  $\frac{1}{2}$  45.  $\frac{1}{2}$  46.  $\frac{1}{2}$  47.  $\frac{1}{2}$  48.  $\frac{1}{2}$  49.  $\frac{1}{2}$  50.  $\frac{1}{2}$  51.  $\frac{1}{2}$  52.  $\frac{1}{2}$  53.  $\frac{1}{2}$  54.  $\frac{1}{2}$  55.  $\frac{1}{2}$  56.  $\frac{1}{2}$  57.  $\frac{1}{2}$  58.  $\frac{1}{2}$  59.  $\frac{1}{2}$  60.  $\frac{1}{2}$  61.  $\frac{1}{2}$  62.  $\frac{1}{2}$  63.  $\frac{1}{2}$  64.  $\frac{1}{2}$  65.  $\frac{1}{2}$  66.  $\frac{1}{2}$  67.  $\frac{1}{2}$  68.  $\frac{1}{2}$  69.  $\frac{1}{2}$  70.  $\frac{1}{2}$  71.  $\frac{1}{2}$  72.  $\frac{1}{2}$  73.  $\frac{1}{2}$  74.  $\frac{1}{2}$  75.  $\frac{1}{2}$  76.  $\frac{1}{2}$  77.  $\frac{1}{2}$  78.  $\frac{1}{2}$  79.  $\frac{1}{2}$  80.  $\frac{1}{2}$  81.  $\frac{1}{2}$  82.  $\frac{1}{2}$  83.  $\frac{1}{2}$  84.  $\frac{1}{2}$  85.  $\frac{1}{2}$  86.  $\frac{1}{2}$  87.  $\frac{1}{2}$  88.  $\frac{1}{2}$  89.  $\frac{1}{2}$  90.  $\frac{1}{2}$  91.  $\frac{1}{2}$  92.  $\frac{1}{2}$  93.  $\frac{1}{2}$  94.  $\frac{1}{2}$  95.  $\frac{1}{2}$  96.  $\frac{1}{2}$  97.  $\frac{1}{2}$  98.  $\frac{1}{2}$  99.  $\frac{1}{2}$  100.  $\frac{1}{2}$